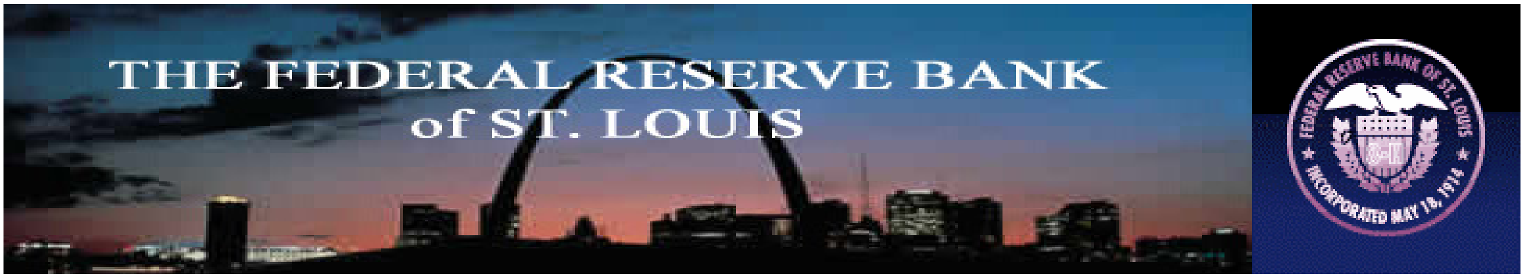

WORKING PAPER SERIES

Some Evidence on Selecting an Intermediate Target of Monetary Policy

Lawrence S. Davidson
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by

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Research Paper No. 82-010

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Preliminary: Please do not quote without author's permission.
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I. Introduction

The purpose of monetary policy is to influence the evolution of the economy. This influence may be expressed in the oft heard phrases of reducing inflation, promoting real economic growth and lowering unemployment. These are the goals of policy action. How are these goals to be achieved?

The Federal Reserve is limited in its power in that there are only a few policy vehicles over which it exercises dominance. Although the main policy instrument of the Fed has differed over time, during the past few decades Fed policy has been exerted primarily through its control of the banking system's reserves via open market operations. The difficulty faced by the policymaker is to know just what effect the changes in the instruments are having on the economy. Since data on the goal variables generally are received with a lag, it is useful to find an intermediate variable that is more timely in its availability and that acts as a good proxy for the goal variable. In other words, changes in the intermediate variable should reliably predict changes in the goal measure. If, however, a measure is unduly influenced by the goal variable, then its usefulness in policy decisions is diminished greatly. This is because movements in the intermediate measure might emanate from policy actions, from changes in the goal measure, or both. For a measure to be useful as an intermediate target, therefore, it should have the feature of being "exogenous" or causally prior to the goal variable.

In addition to having minimal feedback from the goal measure, the intermediate target measure also should respond predictably to changes in the direction of policy. For example, an intermediate target that responds randomly to changes in the policy instrument is useless in determining the eventual impact on the goal measures. Thus, a practical intermediate target logically is one that closely mirrors changes in policy reflected in movements of the policy instrument.

The crucial position of the intermediate target in the monetary policy scenario has been stressed in a number of works.[1/] For the most part, previous empirical investigations have focused on only one aspect of a target variable; i.e., examining the predictability of the target-goal relationship, or examining the instrument-target link.[2/] Moreover, previous work has dealt primarily with the capabilities of monetary aggregates, interest rates or both as intermediate targets. Recent work by Benjamin Friedman [1981a, b, 1982] expands this list of candidates to include broad credit measures. His evidence, based on data taken from the period 1953-80 and vector-autoregression tests, suggests that there is a reliable correlation between movements in several broad credit measures and GNP. Consequently, the evidence leads him to argue for giving much more weight to movements in these measures in the conduct of monetary policy.[3/]

The purpose of this paper is to re-examine the evidence as it pertains to the two aspects cited for a useful intermediate target; namely, that it is causally prior to the goal variable, and that it is closely related to changes in the policy instrument. To do this, we empirically examine several possible measures, expanding the investigation to incorporate the recent findings by Friedman. The variables studied here, therefore, are M1, M2 (new definitions), the federal funds rate (FFR) and three credit measures studied by Friedman--total nonfinancial debt (TNFD), total debt (TD) and non-federal debt (NFEDD). An additional measure, denoted M2A, also is used. This measure consists of the non-M1 components of M2 and is used to examine those measures that many argue are close substitutes for M1-type deposits.

Our investigation is presented in two parts. The first part, which comprises Section II, examines the causal relationship between the proposed intermediate target (hereafter target) measures and economic activity. While most previous investigations have relied heavily on the predictability of the relationship between the target and nominal GNP, we conduct our investigation using both nominal and real GNP as goal variables. This approach, we believe, is superior since observing only the causal relationship between the target variable and nominal GNP may confound the relationship between changes in the target and prices and output. Moreover, since policy makers are concerned primarily with the pace of economic activity in setting short-run policy, it is important to use real GNP as the variable of interest.[4/]

The second part of our study is contained in Section III. There we investigate the issue of controllability. Using the adjusted monetary base as the instrument variable, we test for the relative closeness of movements in the targets and the adjusted base. Anticipating our results, the evidence indicates that movements in M1 and the adjusted base are much closer than any of the other measures tested. Section IV offers some policy implications and concluding remarks.

II. Causality Tests

The usefulness of any measure as a policy target rests on the fact that it is causally prior to the goal variable. If this criterion is not met, movements in the target variable may reflect the combined influence of policy actions and movements in the goal variable not directly attributable to desired policy changes. For example, if the target variable both causes and is caused by the goal variable, then it does not provide an unambiguous signal of where policy actions are headed.

The test utilized in this study comes from the work of Granger [1969]. Granger's test procedure is based on the premise that if predictions of variable Y obtained using past values of both Y and another variable X are statistically superior to forecasts obtained using only past values of Y, then X is said to "cause" (in Granger's sense) Y. More formally, let $P(t)\,(Y|U)$ be the optimal, unbiased prediction U given that all the relevant information accumulated since t-1 is known. The relevant error series $\varepsilon(t)$ is defined as $\varepsilon(t)(Y|U) = Y(t) - P(t)(Y|U)$. Denoting the variance of the error series as $\sigma^2(Y|U)$, X "Granger causes" Y if the variance of $\varepsilon(t)$ is less when past X are included in the equation compared to only past Y. If (U-X) is the information set that <u>excludes</u> past X, then Granger causality from X to Y occurs when the condition $\sigma^2(Y|U) < \sigma^2\,(Y|U-X)$ is satisfied.

This is a necessary but not sufficient condition, however. Feedback from Y to X occurs when we find that $\sigma^2(Y|U) < \sigma^2(Y|U-X)$ and $\sigma^2(X|U) < \sigma^2(X|U-Y)$ occur simultaneously. For a variable to be useful as a policy target, unidirectional causation from it to the goal variable is a necessary condition.

To test the causal relationship between our hypothesized targets and the goal variables, the following equations are estimated:

$$(1) \quad Y(t) = \sum_{j=1}^{n} \alpha_j Y(t-j) + \sum_{i=1}^{m} \beta_i X(t-i) + \varepsilon(t)$$

$$(2) \quad X(t) = \sum_{i=1}^{m} \lambda_i X(t-i) + \sum_{j=1}^{n} \delta_j Y(t-j) + \eta(t)$$

where α_j, β_i, λ_i and δ_j are parameters to be estimated, $\varepsilon(t)$ and $\eta(t)$ are white noise error processes; $E[\varepsilon(t), \varepsilon(s)] = 0$, $E[\eta(t), \eta(s)] = 0$ and $E[\varepsilon(t), \varepsilon(s)] = 0$ for all $t \neq s$. From equations (1) and (2) unidirectional causation from X to Y is implied if $\sum_{i=1}^{m} \beta_i \neq 0$ and $\sum_{j=1}^{n} \delta_j = 0$. Feedback from Y to X exists when $\sum_{i=1}^{m} \beta_i \neq 0$ and $\sum_{j=1}^{n} \delta_j \neq 0$.[5/]

The time series Y and X should exhibit properties of stationarity. In other words, the stochastic process generating the observed Ys and Xs are assumed to have means and variances that are time invariant. Previous analyses have approached this problem in several ways. Sargent [1976], for example, uses log-level data and enters a time trend variable as an explanatory variable. Other have attempted to meet this requirement through more elaborate data filtering processes [see, for example, Sims (1972) and Mehra (1978)]. Since the desired outcome is that $\varepsilon(t)$ and $\eta(t)$ be white noise, we have chosen to use first-differenced logarithms, because it was found that this transformation satisfied this condition.[6/] Moreover, because policy deliberations are couched in terms of growth rates, use of growth rates seems appropriate.

II.1 Empirical Results

The tests performed in this section use seasonally adjusted, quarterly observations of the relevant variables. The regressions are estimated for the period I/1960 to IV/1980.[7/] As mentioned previously, all data are measured as first-differenced logarithms.

The format of our testing is to first determine the optimal autoregressive structure for each variable. This is a necessary step in application of the Granger test procedure. Using the suggested autoregressive structures, we then examine the relationship between nominal GNP growth and the target variables. Following this, we turn our attention to testing the causal link between the targets and real GNP growth.

II.1a Selecting the Autoregressive Structure

Prior to estimating equations (1) and (2), it is necessary to determine the autoregressive structure for each of the variables. Due to the large number of variables and possible lag patterns, we limited our tests to the relative superiority of 4 versus 8 lags. The tests were conducted using a standard F-test.[8/] Since serial correlation in the nominal GNP growth causes changes in M2A, the federal funds rate (FFR) and total non-financial debt (TNFD). This implies bidirectional causation from GNP to the federal funds rate and M2A, and unidirectional causation from GNP to total non-financial debt. Consequently, none of these measures meet the criterion of a target measure previously set forth.

At higher levels of significance, unidirectional causation from M1 and M2 to GNP also is questioned. For instance, although the calculated F-statistic using 4 lags of GNP indicates that M1 unidirectionally causes GNP, the finding based on 8 lags of GNP reverses this finding and provides some evidence in favor of a bidirectional relationship.[10/] The same is true for the M2 measure, except that the results in table 3 indicate a much more likely rejection of the hypothesized M2-to-GNP causal link due to the large F-statistics reported for both the 4 and 8 lags on GNP.

The results for the remaining variables--total debt and non-federal debt--again reveal an ambiguous effect. Combined with the results in table 2, these findings suggest an independent relationship between movements in GNP and these variables. The same is probably true for total non-financial debt, too. The finding of insignificant F-values suggests that changes in these variables will not influence GNP nor are they influenced by GNP. In either case, they clearly would not be useful as intermediate targets if the goal is to reliably influence nominal GNP growth.

II.1C Real GNP

A reading of almost any "Record of Policy Actions of the Federal Open Market Committee" reveals that discussions among policymakers and their staff habitually concentrate on real economic growth with regard to near term objectives.[11/] Thus, short-run decisions about policy actions can be viewed as decisions to influence real economic activity and not inflation, per se. If this outlook with respect to short-term policy decisions is accurate, and our personal experience suggests that it is, the proper goal variable is the growth of real GNP. With this in mind, we perform the same tests as before, this time replacing nominal GNP growth by real GNP growth.

The results of reestimating equation (1) using real GNP growth are presented in table 4.[12/] Again 4 and 8 lags are used for each prospective indicator. The reported Q-statistics do not permit rejection of the hypothesis that the error processes can be characterized as white noise. The evidence presented in table 4 suggests that the monetary measures all exert a strong influence on real GNP growth: all of the calculated F-statistics (except for 4 lags on M1) are highly significant and easily surpass 5 percent critical values. The federal funds rate (FFR) also improves upon the autoregressive prediction of real GNP. The most striking result is the failure of the non-monetary measures to provide any reliable information to improving the predictions of real GNP growth. In each instance, the calculated F-statistic is below any reasonable level of significance. Indeed, the results reported in table 4 augment those found in table 2: together they indicate that the debt measures are not viable policy targets, because they demonstrate no statistical ability whatsoever in improving upon the prediction of economic activity, given past information of nominal or real GNP growth. In Granger's sense, therefore, they are not causally prior to the goal variable.

The case against the non-monetary measures is strengthened by the evidence found in table 5, where we report the F-statistics for the testing of equation (2). The evidence there indicates that the growth of total debt (TD) is independent to real GNP growth, the same as was reported for nominal GNP in table 3. The growth of total non-financial debt (TNFD) and non-federal debt (NFEDD), however, appear to be caused by real GNP growth; the F-statistics based on using 4 lags of the independent variables exceed the 10 and 5 percent levels, respectively. Finally, the results for the federal funds rate reported in tables 4 and 5 indicate feedback between real GNP and the interest rate at the 1 percent significance level.

The results using the monetary measures are important. When viewed in conjunction with the evidence presented in table 4, they indicate that only the M1 measure has an unambiguous causal relation to real GNP. For either the 4 or 8 quarter lag length, the F-statistics in table 5 show that changes in the growth of real GNP do not cause M1 growth once past M1 growth is accounted for. In other words, the M1 results imply unidirectional causation from M1 growth to real GNP growth. The same cannot be said, however, for M2 or M2A: the evidence presented in tables 4 and 5 suggests a bidirectional relationship between these broader money measures and real GNP growth. Thus, based on tables 4 and 5, only M1 growth is shown to have the characteristic for an policy target; namely, that it is causally prior to the goal variable.

II.1D Summary of Causation Test Results

A necessary condition for a measure to be considered as an monetary policy target is that it be causally prior to the goal variable. The results using nominal GNP growth as the goal of monetary policy yielded ambiguous evidence. For instance, depending on the lag length, there appears to be some feedback from GNP to M1, M2, M2A and the federal runds rate. The results are not ambiguous, however, with respect to the non-monetary assets: in every instance, GNP is independently related to or is causally prior to the debt measures.

Since nominal GNP may confuse real and price movements, we examined the causal relationship between real GNP growth and the growth rates for the possible targets. The federal funds rate showed strong signs of bidirectional causation. Among the debt measures, it was found that these measures and real GNP moved independently, although some real GNP-to-total nonfinancial debt and non-federal debt causation was evident. Moreover, a relatively strong case emerges for a bidirectional link between real GNP and M2 and M2A. These results, overall, suggest that none of these measures would make useful targets for policy when real GNP is assumed to be the goal. The outcome using M1, however, supports its selection as an policy target. Based on the results in tables 4 and 5, the likelihood of unidirectional causation from M1 to real GNP is greater than for any other measure tested. If real GNP is the goal variable of policymakers as a reading of FOMC minutes suggests, these results favor the use of M1 as the best target measure for monetary policy.

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III. Testing the Controllability of the Proposed Monetary Indicators

In the preceding section the various proposed target measures were tested for their causal relationships to two hypothesized goal variables. The other issue, the one addressed in this section, is that of controllability. In other words, a certain measure is not a useful policy target if it is not controllable by those who set the direction of policy. Thus, even though a variable may be causally prior to changes in the goal variable, if it does not adeqately reflect changes in the policy instrument, then it would not be a viable target by definition.

The controllability issue is examined in a straightforward manner. Taking the adjusted monetary base as the policy instrument, regression analysis is used to assess the reaction of the proposed targets to changes in the adjusted base.[13/] To compare the closeness of the measures' relationship to movements in the adjusted base, we ran the following regression:

(3) $$\Delta \ln X_t = \alpha_0 + \beta_1 \Delta \ln BASE_t + \epsilon_t$$

where the X refers to the different measures tested in this paper.[14/]

Equation (3) was tested using the I/1960 to IV/1980 sample period.[15/] In every instance except when M1 is used, preliminary OLS results indicated significant levels of serial correlation among the residuals. To correct for this, the equations were re-estimated using a first-order generalized least squares procedure. In two cases-- those using non-federal debt and the federal funds rate--a second-order transformation was necessary.

Examining the regression results, presented in table 6, the estimated coefficient on the adjusted base is positive and statistically significant in all cases except when the federal funds rate is used as the dependent variable. In that regression, the estimated coefficient on adjusted base growth assumes a negative and statistically insignificant sign. This suggests that changes in adjusted base growth may have been used to offset undesired movements in the federal funds rate during much of the sample period tested.[16/]

The other regression results found in table 6 indicate that changes in adjusted base growth explain very little of the movements in most of the variables. For example, the highest $\bar{R}^2$ among the non-monetary measures is 0.17 for the total non-financial debt. In contrast, the results for M1 indicate that over 50 percent of its growth is explained by changes in the base. Moreover, the estimated coefficient (0.934) in the M1 equation is not statistically different from unity, a result not shared by any other indicator.[17/] This suggests that a one percentage point change in adjusted base growth will, on average, yield an identical change in M1 growth during the contemporaneous period.

The M2 and M2A results are interesting. Base explains only about 20 percent of the variation in M2 growth and only 6 percent for M2A. Recalling that M2A comprises the non-checkable deposit and non-currency components of M2, this indicates that these measures are not closely related to adjusted base growth: any relationship between adjusted base growth and M2 growth is really due to the base-M1 relationship embodied within the base-M2 test. The non-M1 components of M2 are not, therefore, reliably related to changes in the adjusted base. Thus, the results in table 6 provide evidence indicating that M1 growth is more closely related to base growth than any of the other 7 variables examined. The evidence thus indicates that M1 could be more easily controlled by the policymakers, i.e., it responds more reliably to changes in policy than any of the other measures examined.

It may be argued that equation (3) should permit a lag response for each variable to a given change in the adjusted base growth. To see if a significant lag pattern exists, lags from 1 to 4 were added sequentially. The resulting equation then was compared with the results presented in table 6 by means of an F-test. In only two cases--the equations using total nonfinancial debt and total debt--do the results suggest a longer adjustment period. In each case 3 lags along with the contemporaneous term minimized the standard error of the regression. The regression results for the lagged model are (absolute value of t-statistics in parentheses):

$$\Delta \ln TNFD = \underset{(4.93)}{3.73} + \underset{(4.03)}{0.319}\,\Delta \ln B_t + \underset{(2.05)}{0.156}\,\Delta \ln B_{t-1}$$

$$+ \underset{(1.46)}{0.113}\,\Delta \ln B_{t-2} + \underset{(2.15)}{0.173}\,\Delta \ln B_{t-3}$$

$\bar{R}^2 = 0.34$ $\quad$ SE = 1.12 $\quad$ Q = 18.07 $\quad$ $\hat{\rho} = 0.58$

and

$$\Delta \ln TD = \underset{(4.00)}{3.83} + \underset{(2.91)}{0.289}\,\Delta \ln B_t + \underset{(1.76)}{0.168}\,\Delta \ln B_{t-1}$$

$$+ \underset{(1.68)}{0.163}\,\Delta \ln B_{t-2} + \underset{(2.07)}{0.209}\,\Delta \ln B_{t-3}$$

$\bar{R}^2 = 0.25$ $\quad$ SE = 1.41 $\quad$ Q = 20.21 $\quad$ $\hat{\rho} = 0.58$

There are noticeable differences between these results and those reported in table 6. In both cases, the explanatory power of the the equation is much improved: the $\bar{R}^2$ increases from 0.17 to 0.34 for TD and from 0.08 to 0.25 for TD. The Q-statistics indicate that a first-order GLS correction is sufficient to remove serial correlation at the 5 percent level. It also is instructive to compare the parameter estimates. For example, in table 6 the regression for TNFD indicates that the debt measure's growth rate increases only about 30 percent of a given change in the growth of base. The results above suggest a summed impact of about 75 percent. The result for TD indicates a summed effect of about 80 percent, compared with the 30 percent response reported in table 6. Even so, the results presented above are statistically inferior to those using M1: the equation using M1 has an explanatory power that is 65 percent larger than that for TNFD and about 125 percent greater than the equation using TD. Thus, even though the results are improved over the contemporaneous model reported in table 6, M1 is the measure more reliably related to changes in the adjusted base growth.

One feature to the foregoing analysis is that it assumes a constant multiplier. We relax this assumption and examine the relative variability of each measure's adjusted base multiplier. The variability measures are standardized across ratios by using the coefficient of variation, thereby permitting direct comparison.[18/] Each variables' variability measure for a variety of time periods is presented in table 7.

The first column presents the full-period results; the second and third columns present the evidence for two subperiods. Comparing the results, we see that the multipliers from the more recent subperiod (I/1970-IV/1980) generally reveal a higher level of variability. More important, the lowest variability, irrespective of time period, comes from M1. If variability and forecastability are directly related, as we assume here, this suggests that policy makers can use changes in the adjusted base to predict changes in M1 more accurately than any of the other measures examined. To further test the robustness of these relationships, the full period was divided further into shorter five year intervals. These results, also reported in table 7, again indicate that the ratio of M1 to adjusted base is, on average, the least variable ratio tested. This supports the longer period results and buttresses the regression results reported in table 6.

In summary, we have investigated the issue of controllability by examining the closeness of the relationship between growth rates of the adjusted base and the proposed policy targets. Based on regression analysis and an examination of the respective base multipliers' variability over time, our evidence strongly rejects the use of any measure other than M1 as an intermediate target for monetary policy.

IV. Policy Implications and Conclusion

A long-standing debate centers around the selection of one or more measures as intermediate targets for monetary policy. Two criteria for a variable to function in this capacity are used in this paper: 1) The measure be causally prior to the goal of policy actions and 2) It is reasonably controllable by policy makers.

Based on the recent work of Benjamin Friedman, some policy makers have called for abandoning the use of the narrowly defined monetary measures in favor of broader measures.[19/] The tests reported in this study contradict these arguments. The results indicate that M1 fulfills the conditions necessary for an intermediate target more often than rival measures ɔth monetary and debt. Our evidence suggests that

M1 is causally prior to real economic activity and is related more closely to changes in the adjusted monetary base than to M2, three broad debt measures or the federal funds rate. The period over which our tests are performed is indeed a turbulent one, characterized by large swings in economic activity and unprecedented advances in financial innovations. Even so, the evidence based on Friedman's sample suggests that, more than any other measure tested, M1 more often fulfilled the requirements of an intermediate target.

Footnotes

1/ The importance of determining the best intermediate target measure is discussed in Brunner and Meltzer [1971], Brunner [1969], Friedman [1975] and Kane [1980, 1982].

2/ Studies examining the target-goal relationship are exemplified by Hamburger [1970], Levin [1974], Carlson and Hein [1980] and Hafer [1980]. Studies investigating the controllability issue are Pierce and Thompson [1972], Bomhoff [1977] and Johannes and Rasche [1979, 1981].

3/ Indeed, recent pronouncements by some Fed officials suggest that these arguments are being considered. See Morris [1982].

4/ Real GNP is the variable used most often in studies attempting to capture the Fed's reaction function. See, inter alia, R. Froyen [32].

5/ It is assumed that the relevant information set for predicting the goal variable consists solely of the two GNP measures and our set of candidates for a target measure.

6/ Selecting the appropriate filter is problematic. Sims (1972), for example, advocates the use of the filter $(1-.75B)^2$ based on the contention that it will flatten the spectral density function of most economic time series. Fiege and Pearce (1979) have argued recently that this filter may not be suitable and give misleading test results. Using Sims' test, they find that different filters yield different causality results. It is difficult to generalize from the Fiege and Pearce results, however. What they show is that the Sims test is sensitive to different filters. In their examination of the Granger test, they also use first-differences of logarithms to transform the data into stationary series.

Pierce and Haugh (1977) also address the issue of pre-filtering. The use of first-differences, they note, will usually produce stationary economic time series (see also Box and Jenkins (1970)) and that such a transformation (even when logarithms are used) preserves the causal relationship between the raw data sets. Moreover, they note that "[T]here is ample evidence for choosing '(1-B)' as a factor of this filter for much economic data." (p. 290)

There are, of course, many ways to filter the data. Under-filtering the data may not lead to serially uncorrelated residuals in the test equations which, consequently, will bias the F-tests. Over-filtering the data may introduce serial correlation (negative) into the residual process and again bias the F-tests. Our choice of first-differencing as a filter is based on the finding that this procedure does reduce the model residuals to white noise, and because it is generally recognized to be a sufficient procedure to achieve stationary time series. Clearly, however, one must be cautious in interpreting our results, or those of any other causality investigation, until further research is done using test procedures different from those employed in this paper.

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15/ Chow tests again support use of the full-period results. The outcome of these tests are available upon request.

16/ Indeed, policy before October 1979 explicitly sought to control movements of the funds rate within a narrow band. Thus, the negative sign is not suprising. Even so, the results indicate that there is no reliable quarterly relationship between changes in base and the federal funds rate. Moreover, the Q-statistic indicates the continued presence of serial correlation even after a second-order GLS correction procedure was applied. This finding suggests that the equation may be misspecified, a conclusion supported by the equation's overall explanatory power.

17/ The relevant t-statistics to test the hypothesis that $\beta_0=1$ for the base-M1 equation is 0.72. The statistics for the other variables are: M2(2.80); M2A(2497.5); TNFD(8.51); TD(7.03); NFEDD(7.34); and FFR(15.43).

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19/ See, inter alia, Morris [1982].

References

Bomhoff, E. "Predicting the Money Multiplier," Journal of Monetary Economics (3:1977), pp. 325-45.

Brunner, K., ed. Targets and Indicators of Monetary Policy (San Francisco: Chandler Publishing Co., 1969).

________ and A.H. Meltzer, "The Meaning of Monetary Indicators," in Monetary Economics: Readings on Current Issues.

Carlson, K. and S.E. Hein, "Monetary Aggregates as Monetary Indicators," Federal Reserve Bank of St. Louis Review (November 1980), pp. 12-21.

Federal Reserve Board of Governors, Bulletin (various issues).

Fiege, E.L. and D.K. Pearce, "The Casual Causal Relationship Between Money and Income: Some Caveats for Time Series Analysis," Review of Economics and Statistics (November 1979), pp. 521-33.

Friedman, B. "Targets, Instruments, and Indicators of Monetary Policy," Journal of Monetary Economics (October 1975), pp. 443-74.

________, Monetary Policy in the United States: Design and Implementation Study prepared for the Trustees of the Banking Research Fund. (June 1981a).

________, "The Role of Money and Credit in Macroeconomic Analysis," NBER Working Paper No. 831 (December 1981b).

________, "Time to Reexamine the Monetary Targets Framework," New England Economic Review (March/April 1982), pp. 15-23.

Froyen, R., "Systematic Monetary Policy and Short-Run Real Income Determination," Journal of Economics and Business (vol. 32), pp. 14-22.

Gibson, W.E. and G.C. Kaufman, eds. Monetary Economics: Readings on Current Issues (New York; McGraw Hill, 1971).

Granger, C.W.J. "Investigating Causal Relationships by Economic Models and Cross-Spectral Methods," Econometrica (July 1969), pp. 424-38.

Hafer, R.W. "Selecting a Monetary Indicator: A Test of the New Monetary Aggregates," Federal Reserve Bank of St. Louis Review (February 1981), pp. 12-18.

Hamburger, M.J. "Indicators of Monetary Policy: The Arguments and the Evidence," American Economic Review, Papers and Proceedings (May 1970), pp. 32-9.

Johannes, J.M., and R.H. Rasche, "Predicting the Money Multiplier," Journal of Monetary Economics (5:1979), pp. 301-25.

________, "Can the Reserves Approach to Monetary Control Really Work?" Journal of Money, Credit and Banking (August 1981), pp. 298-313.

Kane, E.J., "Politics and Fed Policymaking: The More Things Change the More they Remain the Same," Journal of Monetary Economics (April 1980), pp. 199-211.

________, "Selecting Monetary Targets in a Changing Financial Environment," paper presented at "Monetary Policy Issues in the 1980s" Conference, sponsored by the Federal Reserve Bank of Kansas City, 1982.

Komura, C. "Money, Income, and Causality: The Japanese Case," Southern Economic Journal (July 1982), pp. 19-34.

Levin, F.J. "The Selection of a Monetary Indicator: Some Further Empirical Evidence," Monetary Aggregates and Monetary Policy (Federal Reserve Bank of New York, 1974), pp. 35-9.

Mehra, Y.P. "Is Money Exogenous in Money Demand Equations?" Journal of Political Economy (April 1978), pp. 211-28.

Morris, F.E. "Do the Monetary Aggregates Have a Future as Targets for Federal Reserve Policy?" New England Economic Review (March/April 1982), pp. 5-14.

Pierce, D.A. and L.P. Haugh, "Causality in Temporal Systems: Characterizations and a Survey," Journal of Econometrics (May 1977), pp. 265-93.

Pierce, J.L. and T.D. Simpson, "Some Issues in Controlling the Stock of Money." In Controlling the Monetary Aggregates II: The Implementation, pp. 115-36. Boston: Federal Reserve Bank of Boston Conference Series No. 9, 1972.

Sargent, T. "A Classical Macroeconomic Model for the United States," Journal of Political Economy (April 1976), pp. 207-37.

Sims, C.A. "Money, Income, and Causality," American Economic Review (September 1972), pp. 540-52.

Table 1
Autoregressive Models
F-test for additional lags: 4 vs. 8

Variable	Q [1/] 4	8	Calculated F [2/]
GNP	15.00	9.77	3.09*
RGNP	12.40	6.14	2.05
M1	9.01	2.87	2.82
M2	10.89	4.06	2.20
M2A	7.38	3.80	1.54
TNFD	15.11	4.99	1.95
TD	14.93	5.32	2.28
NFEDD	11.26	3.31	3.06*
FFR	5.87	2.69	1.46

1/ Q is the Ljung-Box Q-statistic for serial correlation. It is distributed as a χ^2 with 12 degrees of freedom.

2/ The F-statistic is calculated using the formula

$$\frac{SSR_R - SSR_u}{SSR_u} \cdot \frac{N-K}{Q}$$

where SSR_R is the residual sum of squares from the restricted equation, SSR_u the residual sum of squares from the unrestricted equation, N is the number of observations, K the number of regressors in the unrestricted equation and Q is the number of restrictions. The asterisk denotes significance at the 5 percent level for an F distributed at (4,71) degrees of freedom.

Table 2
Granger Test Results: $GNP_t = f(GNP_{t-i}, X_{t-i})$
1960/I-1980/IV

Independent Variable	Lag Form	Q [1/]	F [2/]
M1	4	7.13	2.21*
	8	9.63	1.78*
M2	4	8.47	1.75
	8	9.69	2.34**
M2A	4	8.24	1.00
	8	8.50	2.26**
TNFD	4	5.77	1.16
	8	5.03	1.21
TD	4	5.88	1.07
	8	6.82	1.00
NFEDD	4	8.93	0.70
	8	9.01	0.50
FFR	4	7.89	4.89***
	8	9.46	4.41***

1/ Q is the Ljung-Box Q-statistic for serial correlation. It is distributed as a χ^2 with 12 degrees of freedom.

2/ The calculated F-statistic is determined as (4,67) for four lags of the independent variable and (8,63) for eight lags of the independent variable: * denotes significance at the 10 percent level, ** represents the 5 percent significance and *** marks significance at the 1 percent level.

Table 3
Granger Test Results: $X_t = f(X_{t-i}, GNP_{t-i})$
1960/I-1980/IV

Dependent Variable	GNP Lag Form	Q [1/]	F [2/]
M1	4	4.47	1.37
	8	4.61	2.16**
M2	4	11.51	2.60**
	8	11.09	3.06**
M2A	4	9.93	2.19*
	8	9.42	2.22**
TNFD	4	14.34	1.10
	8	13.81	1.78*
TD	4	11.91	0.54
	8	14.03	1.04
NFEDD	4	3.57	0.94
	8	5.74	0.81
FFR	4	6.23	2.08*
	8	4.97	1.62

1/, 2/, See notes following table 2.

Table 4
Granger Test Results: $RGNP_t = f(RNGP_{t-i}, X_{t-i})$
1960/I-1980/IV

Independent Variable	Lag Form	Q [1/]	F [2/]
M1	4	13.18	1.59
	8	12.42	2.64**
M2	4	10.27	5.18***
	8	12.53	3.69***
M2A	4	9.04	4.65***
	8	11.49	3.77***
TNFD	4	8.73	0.79
	8	5.82	1.09
TD	4	8.69	1.56
	8	7.63	1.33
NFEDD	4	10.50	1.57
	8	12.05	1.13
FFR	4	10.76	12.13***
	8	11.15	6.07***

1/, 2/ See notes to table 2.

Table 5
Granger Test Results: $X_t = f(X_{t-i}, RGNP_{t-i})$
1960/I-1980/IV

Dependent Variable	RGNP Lag Form	Q [1/]	F [2/]
M1	4	3.45	0.68
	8	3.36	1.31
M2	4	11.91	1.53
	8	10.90	2.19**
M2A	4	10.46	1.96*
	8	9.77	2.08**
TNFD	4	11.97	2.03*
	8	11.36	1.25
TD	4	7.58	1.92
	8	8.45	1.20
NFEDD	4	3.77	2.25**
	8	4.30	1.21
FFR	4	7.28	2.86**
	8	6.47	2.44**

1/, 2/ See notes following table 2.

Table 6
Regression Results: 1960/I-1980/IV
Equation Tested: $\Delta \ln X_t = \alpha_0 + \beta_1 \Delta \ln BASE_t + \epsilon_t$

	Coefficients		Summary Statistics			
Dependent Variable	α_0	β_0	$\bar{R}^2$	SE	Q(12)	$\hat{\rho}$
M1	-0.543 (0.91)	0.934 (10.26)	0.56	1.97	6.77	---
M2	4.339 (4.21)	0.616 (4.49)	0.19	2.03	12.89	0.65
M2A	0.018 (4.99)	0.001 (2.56)	0.06	0.01	12.17	0.76
TNFD	6.226 (8.16)	0.332 (4.23)	0.17	1.13	10.98	0.52 0.29
TD	6.954 (7.46)	0.295 (2.94)	0.08	1.44	12.69	0.58 0.21
NFEDD	7.301 (8.95)	0.289 (2.99)	0.09	1.39	28.27*	0.56 0.19
FFR	8.584 (2.16)	-0.099 (1.39)	0.01	1.17	24.57*	1.20 -0.22

1/ $\bar{R}^2$ is the coefficient of determination adjusted for degrees of freedom, SE is the regression standard error, Q is the Box-Ljung Q-statistic and $\hat{\rho}$ is the estimate of the serial correlation coefficient. The (*) indicates that we cannot reject the hypothesis of serially correlated errors at the 5 pecent level.

Table 7
Coefficient of Variation for Multiplier Ratios

Ratio	Period						
	I/1960-IV/1980	I/1960-IV/1969	I/1970-IV/1980	I/1960-IV/1964	I/1965-IV/1969	I/1970-IV/1974	I/1975-IV/1980
M1/BASE	0.062	0.026	0.048	0.014	0.008	0.019	0.018
M2/BASE	0.118	0.072	0.066	0.056	0.020	0.039	0.037
M2A/BASE	0.208	0.133	0.111	0.106	0.035	0.063	0.055
TNFD/BASE	0.120	0.057	0.076	0.040	0.022	0.029	0.055
TD/BASE	0.152	0.066	0.096	0.044	0.027	0.042	0.067
NFEDD/BASE	0.160	0.098	0.074	0.061	0.039	0.044	0.053
FFR/BASE	0.317	0.290	0.344	0.214	0.225	0.317	0.289

Appendix A
Table A1
Chow Test Results: $GNP_t = f(GNP_{t-i}, X_{t-i})$
Break Point Tested: IV/1969

Independent Variable	Lag Form	F[1/]
M1	4	0.63
	8	0.37
M2	4	0.88
	8	0.90
M2A	4	0.59
	8	1.34
TNFD	4	0.93
	8	1.03
TD	4	1.28
	8	1.34
NFEDD	4	0.84
	8	0.99
FFR	4	0.82
	8	0.58

1/ Critical 5 percent value for lag form 4 is 1.84; for lag form 8 is 1.82

Table A2
Chow Test Results: $X_t = f(X_{t-i}, GNP_{t-i})$
Break Point Tested: IV/1969

Dependent Variable	GNP Lag Form	F 1/
M1	4	1.05
	8	1.11
M2	4	0.79
	8	0.99
M2A	4	0.68
	8	0.94
TNFD	4	1.04
	8	1.00
TD	4	1.71
	8	1.46
NFEDD	4	1.60
	8	1.30
FFR	4	0.98
	8	1.14

1/ See notes accompanying table A1.

Appendix B
Table B1
Chow Test Results: $RGNP = f(RGNP_{t-i}, X_{t-i})$
Break Point Tested: IV/1969

Independent Variable	Lag Form	F[1/]
M1	4	0.52
	8	0.52
M2	4	0.57
	8	0.66
M2A	4	0.55
	8	0.53
TNFD	4	0.42
	8	1.03
TD	4	0.73
	8	1.02
NFEDD	4	0.46
	8	0.62
FFR	4	0.88
	8	0.69

1/ Critical 5 percent value for lag form 4 is 1.88; for lag form 8 it is 1.84.

Table B2
Chow Test Results: $X_t = f(X_{t-i}, RGNP_{t-i})$
Break Point Tested: IV/1969

Dependent Variable	RGNP Lag Form	F1/
M1	4	1.36
	8	1.20
M2	4	0.71
	8	0.93
M2A	4	0.68
	8	0.88
TNFD	4	1.19
	8	0.91
TD	4	1.81
	8	1.50
NFEDD	4	1.99*
	8	1.59
FFR	4	1.55
	8	2.17*

1/ See notes accompanying table B1. * inicates significance at 5 percent level.